

Composting: A Durable Technology for Disinfection of Organic Residuals in an Era of Emerging and Re-Emerging Pathogens

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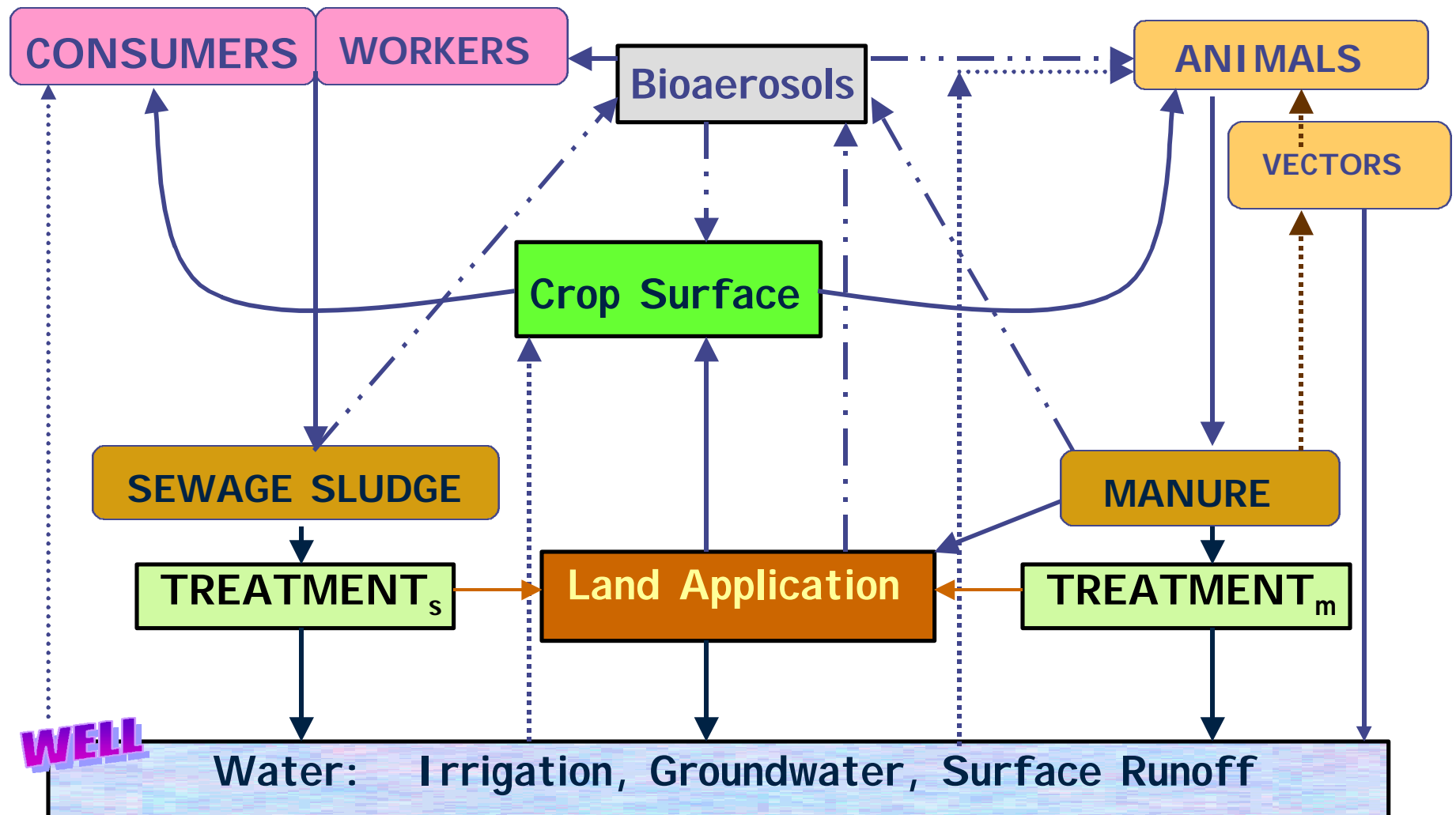
Synopsis of EPA/USDA Workshop 2001

- ◆ Pathways of disease transmission
- ◆ Pathogens and indicator organisms
- ◆ Treatment Technologies / Disinfection
- ◆ Regrowth and Prevention
- ◆ Knowledge gaps and future focus

POTENTIAL ENVIRONMENTAL AND HEALTH CONCERNS WITH PATHOGENS FROM ORGANIC RESIDUES

- **Ground water contamination**
- **Surface water contamination**
- **Edible food crops eaten raw**
- **Residuals taken off farms for commercial use**
- **Bioaerosols and airborne transmission**
- **Vector dissemination**

Sources and Pathways of Pathogen Dissemination



Four Groups of Pathogens involved in Emerging Infectious Disease

◆ Bacteria

◆ Parasites

◆ Viruses

◆ Prion Proteins

Bacteria

◆ High Priority

- Enterohemorrhagic and related *E. coli*
- *Salmonella*
- *Listeria monocytogenes*
- *Campylobacter*

- Medium Priority

- *Yersinia enterocolitica*
- *Clostridium perfringens*
- other pathogenic *E. coli*

- Low Priority

- *Mycobacterium av. paratuberculosis*

Parasites

◆ High Priority

- *Cryptosporidium parvum* (bovine, swine, sheep)
- *Giardia lamblia* (bovine & swine)

• Medium Priority

- Toxoplasma (cats)
- Microsporidia
- *Ascaris suum* (swine)

• Low Priority

- Balantidium (swine)

Viruses

◆ High Priority

- Rotavirus - groups A & B (bovine, swine)
- Hepatitis E virus (swine & rats)
- Myxovirus (swine & poultry)

- Medium Priority

- Reovirus - type 3 et al.
- Enterovirus (bovine, swine)
- Calicivirus (bovine, swine)

- Low Priority

- Herpes, Corona, Parvo, Paramyxa,
- Hepadna, Retro
- Vector borne viruses

Prions

- ◆ **Proteins:** cellular (PrP^c) and PrP^{Sc}
 - PrP^c : Sialoglycoprotein bound to cell surface via glycosyl phosphatidyl-inositol anchor
 - PrP^{Sc} : proteinase K resistance (partial) and insoluble in non-ionic detergents
- ◆ **Diseases in animals** (PrD)
 - Scrapie: sheep
 - TME: transmissible mink encephalopathy, mink
 - CWD: chronic wasting disease, elk/deer
 - BSE: bovine spongiform encephalopathy, bovines
 - FSE: feline SE, cats (pets and zoos)
 - mCJD: murine CJD, mouse or rat (test subjects)



Indicator Organisms

◆ Uses

- Presence/persistence
- Treatment technology effectiveness

◆ Characteristics

- Representative of pathogens, but conservative
 - ◆ more resistant than pathogen
- Present in all manures, biosolids, residuals, tissues
- Easily detectable by a reliable method
- Susceptible to destruction technologies

Indicator Organisms

◆ Presence

- No single indicator
- Indicators á pathogens
- Fecal Coliforms or *E. coli*

◆ Treatment

- Suggested indicators
Bacteria
 - ◆ *B. subtilis*
 - ◆ *Clostridium*
 - ◆ *Enterococci*
- Viruses
 - ◆ Enterovirus
 - ◆ Reovirus
- Prions: PrP only in cases of identified mortalities and sheep offal

Treatment Technologies

- Bacterial Disinfection

Treatment	Log Reduction	Stress	Relative Cost
Lagoon	1 - 3	time	M
Const. Wetland	2 - 3	time, filtration	M
Deep Stack	1 - ?	NH ₃ , heat	L - M
Digestion			
- Mesophilic	1 - 2		M
- Thermophilic	5	time; heat	H
Composting	1 - 5	heat, time	L - M
Air Dry	1 - 2	dessication	L - M
Heat Dry	4 - 5	heat, dessication	H
Pasteurization	5	time, heat	H
Alkaline Process	3 - 5	heat, NH ₃	M

Treatment Technologies - Virus

Treatment	Log Reduction	Animal Systems
Lagoon	1-3	beef, dairy, swine
Const. Wetland	1-2	beef, dairy, swine
Deep Stack	?	poultry, beef, dairy
Digestion		
- Mesophilic	1-2	
- Thermophilic	3->4	beef, dairy, swine
Composting	1-5	All
	1-2 pH<11	
Alkaline process	3-4 pH>11	All
	3-4 55-60°C	
Thermal Process	>4 >60°C	All
Drying and Dry Storage	<1 at >3% Moisture >3 at <1% Moisture	All

LIMITING CONDITIONS FOR PATHOGEN GROWTH

Pathogen	Min. pH	Max. pH	Min. temp	Max. temp
<i>Bacillus cereus</i>	4.3	9.3	4 °C	55 °C
<i>Campylobacter jejuni</i>	4.9	9.5	30 °C	45 °C
<i>Clostridium perfringens</i>	5.0	9.0	10 °C	52 °C
<i>Escherichia coli</i> (enteropathogenic strains)	4.0	9.0	7 °C	49.4 °C
<i>Listeria monocytogenes</i>	4.4	9.4	0.4 °C	45 °C
PrProtein	?	12-14	?	>600°C
<i>Salmonella</i> spp.	3.7	9.5	5.2 °C	46.2 °C
<i>Shigella</i> spp.	4.8	9.3	6.1 °C	47.1 °C
<i>Staphylococcus aureus</i>	4.0	10.0	7 °C	50 °C
<i>Vibrio cholerae</i>	5.0	10.0	10 °C	43 °C
<i>Vibrio parahaemolyticus</i>	4.8	11.0	5 °C	44 °C
<i>Yersinia enterocolitica</i>	4.2	10.0	-1.3 °C	42 °C

SOURCE: US FDA, except PrPtotein (Sreevatsan, 2002)

Prion Inactivation

- ◆ Presence: mostly in brain and spinal cord
- ◆ Treatments to Inactivate
 - Hardy and difficult to destroy (PrP^{Sc})
 - ◆ Boiling or autoclaving alone are insufficient
 - ◆ Prolonged proteolytic enzyme digestion (partial)
 - ◆ High pH lime for 1 hr gives 1 log₁₀ reduction
 - ◆ Slow decay in soil: 1% detected after 3 yr
 - ◆ Guanidine thiocyanate (>0.75), >3M Urea, pH=10 decreased protease resistance of PrP^{Sc}
 - Dry heat: incineration >600 °C is effective
 - Sodium hydroxide + pressure autoclaving, 132 °C is effective

Types of Composting

- ◆ Static Actively Aerated Pile

- ◆ Agitated Bay

- ◆ In-Vessel

- ◆ Windrow

- ◆ Bin

- ◆ Static Passively Aerated Pile

- ◆ Vermi-compost





Advanced Alkaline Stabilization

Alkaline
Admixture

+

Solids



pH > 12, 24 hr
Solids > 50%
Heat pulse: 52-60 C,
12 hr

Organic
Ag Lime

Pathogen destruction

Odor adsorption

Low available P



Alkaline Stabilized Manure Products

- Disinfection levels equivalent to Class A biosolids products
- Reduced Odor
- Decreased soluble P
- Enhanced physical properties
- Added Agricultural Value
- Cost effective processing



Beltsville Alkompro Technologies

- ◆ Hybrid Alkaline and Compost treatment

- ◆ Alkaline Treatment

- pH 12 + heat, 24-72 hr.

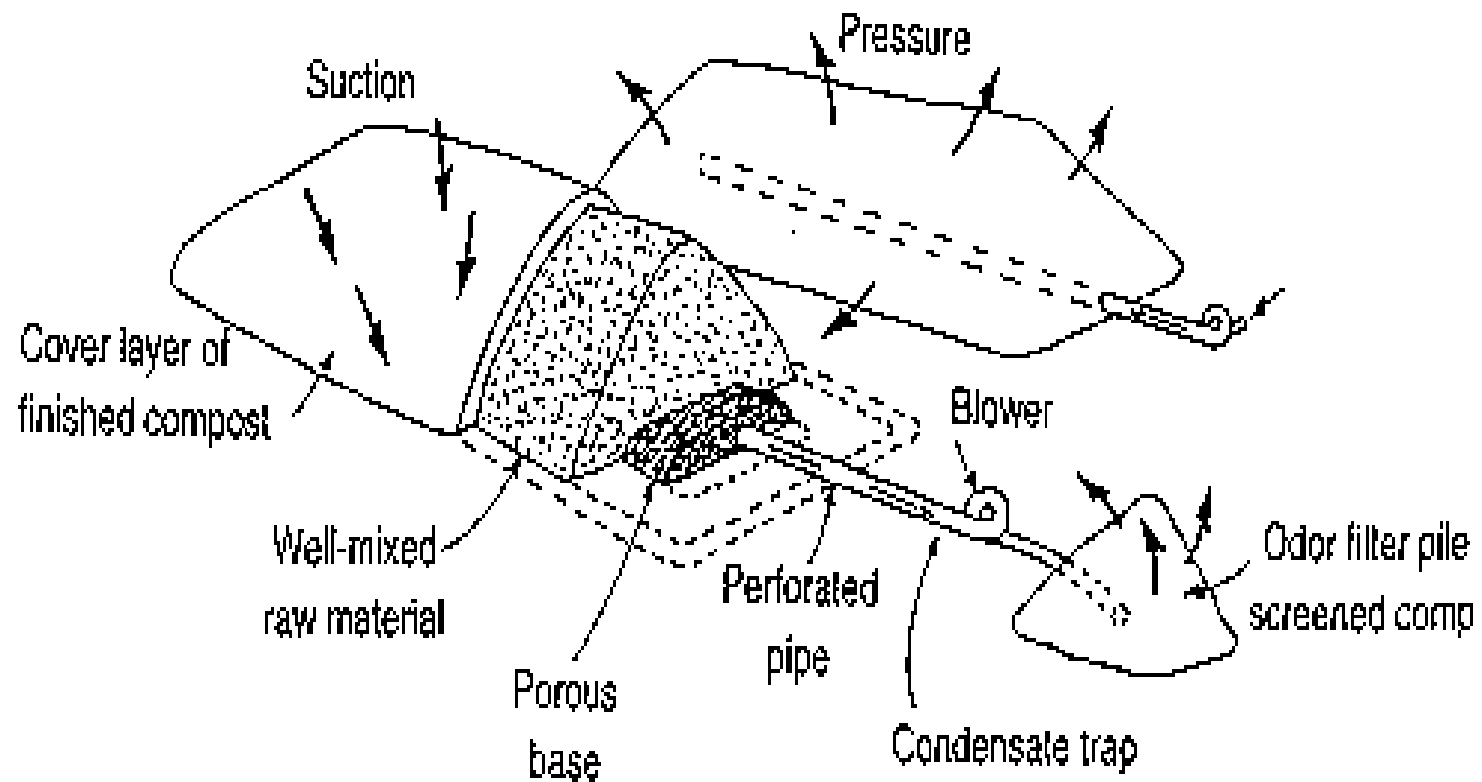
- ◆ Ammonia + heat

- ◆ Thermophilic Composting

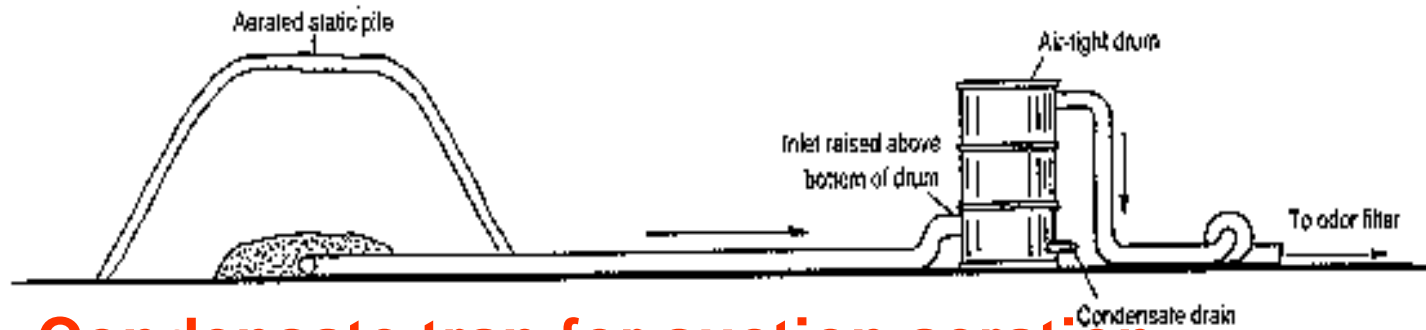
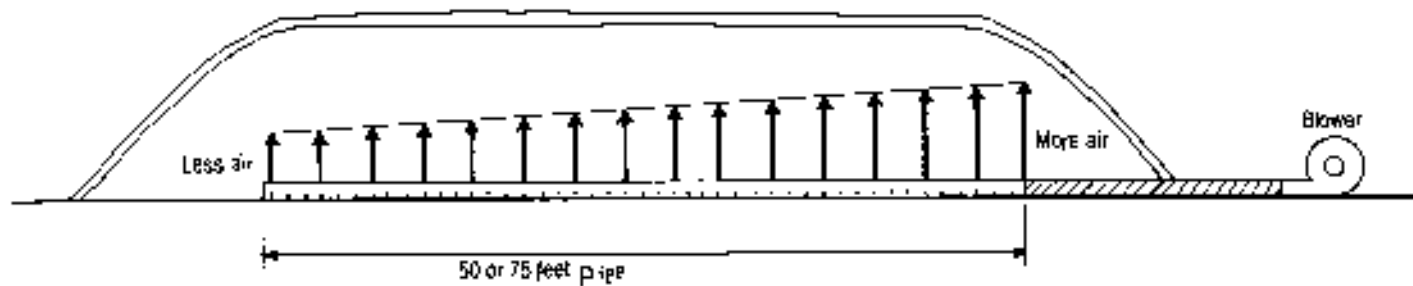
- Mix alkaline treated material with C sources
- Heat: 55-70 C via self heating
- Proteolysis
- Extended time: 60+ days, if necessary, via C & N recharges



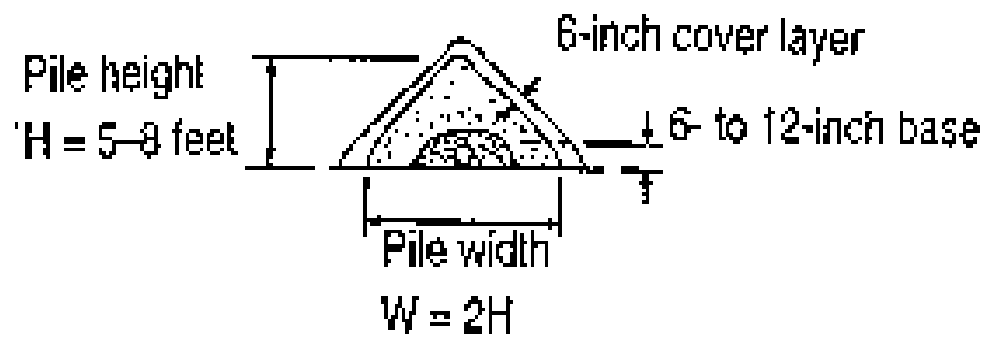
Static Aerated Pile



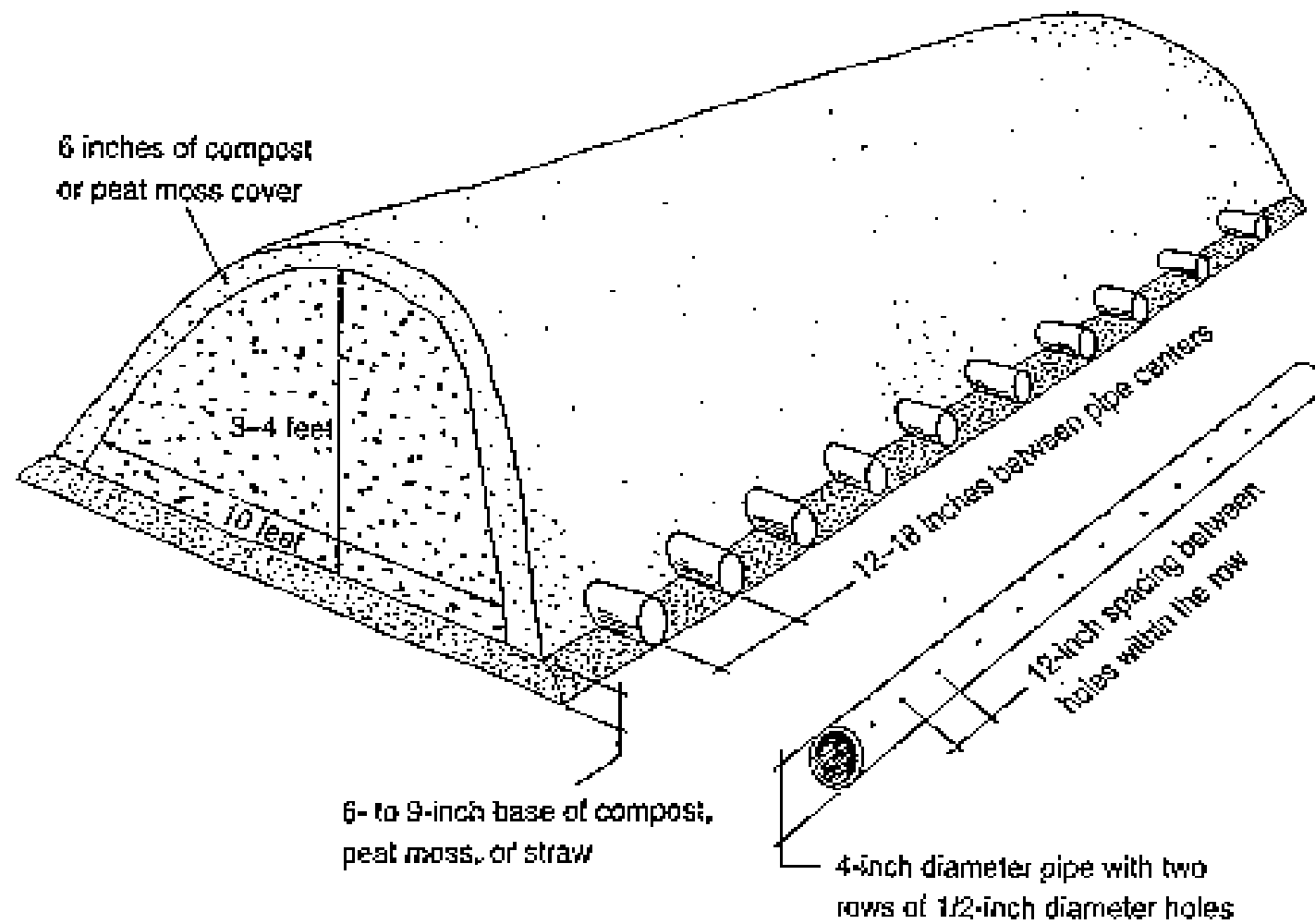
Air Distribution Pattern along Pile Length



Condensate trap for suction aeration



Aerated static pile layout and dimensions.



Mature Sheep Composting Tests -

Canada

Dchaw@admin.oldscollege.ab.ca

- *Sheep offals, heads, and mortalities from slaughterhouse*
- *Unloaded onto a layer of coarse woodchips (hog fuel) and sawdust. Additional wood chip amendment was added until a 1:1 (v/v) ratio was achieved.*
- *Offals and woodchip/sawdust were loaded into mixer and allowed to homogenize.*
- *Mixer is a modified agricultural feed mixer with three augers for blending the material.*
- *Auger mixers ripped open the stomachs facilitating the composting process.*
- *On occasion whole carcasses were also placed in the mixer.*
- *Based on subjective observations, more wood chips were added during mixing to ensure adequate porosity.*

Operational Costs-Sheep Composting in Canada

Dchaw@admin.oldscollege.ab.ca

Item	Rate/Unit	Units	Total
Transportation			\$10,400
Technician mixing delivery	\$40/hr	159	6,360
Technician rotating bunkers	\$40/hr	57	2,280
Skid Steer Rental	\$35/hr	117	4,095
Landfill Tipping Fees	\$35/tonne	60	2,100
Transport to Landfill-340km	\$636/trip	2	1,272
Amendment Cost	\$250/load	3	750
Pathogen indicator species	\$160/batch	10	1,600
Total Operational Costs			\$28,857
Total Number Sheep	48/wk	2538	
Total animal inputs	1.84 tonnes/wk	53 wks	86.7 tonnes
Composting cost	\$11.37/head		

Mature Sheep Composting Tests - Canada

Dchaw@admin.oldscollege.ab.ca

- ◆ Concrete bunkers (filled wkly, 20 cu.m.+)
- ◆ Thermocouples in pile, 30 min datalog
- ◆ Blowers ON when pile is 70 C
- ◆ O₂, moisture, pH, microbe counts
- ◆ Thermophilic range, 45-65 C, 75-80C
- ◆ Recontamination by fecal coliforms
after peak heat achieved
- ◆ Prion analysis in progress

Knowledge Gaps and Future Paths

1. Better Disinfection Methods

1. Combined technologies: alkaline pH and prolonged composting, + decomposer consortia enrichment
2. Sampling different scenarios and matrices

2. Improved Detection Methods

1. Reproducible recovery
2. Infectivity assay
3. Molecular, immunological, IMS
4. Surrogate / indicator comparability

3. Survival: Time/temp/concentration

4. Improved management practices

1. Cross contamination of handling equipment and facilities



Summary

- ◆ Pathways of disease transmission
- ◆ 4 Pathogen Groups and Indicators
- ◆ Treatment Technologies / Disinfection
- ◆ Management Practices
- ◆ Knowledge gaps and future focus



